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(71) Applicant: **SGS-THOMSON
MICROELECTRONICS S.r.l.**
Via C. Olivetti, 2
I-20041 Agrate Brianza (Milano) (IT)

(72) Inventor: **Botti, Edoardo**
Via Battu, 16/D
I-27029 Vigevano (IT)
Inventor: **Chiozzi, Giorgio**
Via Guardì, 50
I-20092 Cinisello Balsamo,
Milan (IT)

(74) Representative: **Maggioni, Claudio et al**
c/o **JACOBACCI & PERANI S.p.A.**
Via Visconti di Modrone, 7
I-20122 Milano (IT)

(54) **Class AB output amplifier stage.**

(57) An AB class stage is described which comprises two complementary MOSFET final transistors (Q_{pf} , Q_{nf}) connected in a push-pull manner between two supply terminals ($+V_{cc}$, $-V_{cc}$). In order to attain high linearity, low switching distortion, a high ratio between the maximum output current and the rest current, independence of the rest current from the temperature and manufacturing variables and a circuit simplicity, the circuits determining the rest current and those which provide current to the load are substantially independent of one another. More particularly, two transconductance amplifiers (T_p , T_n) are provided which control the final transistors (Q_{pf} , Q_{nf}) and are dimensioned so as to have zero output current in rest conditions, two voltage generators ($V_{ref}(Q_{pf})$, $V_{ref}(Q_{nf})$) which determine the rest current and two resistors (R_p , R_n) being connected between the gate electrodes of the final transistors and the supply terminals ($+V_{cc}$, $-V_{cc}$)

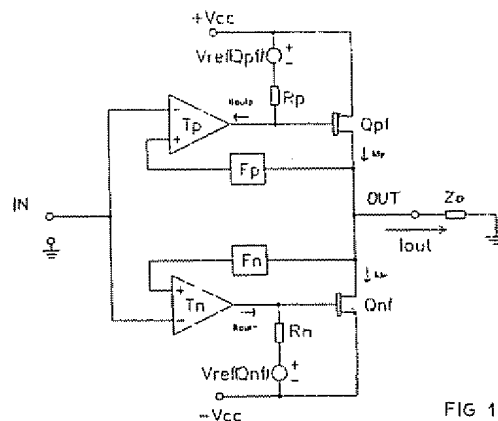


FIG 1

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The present invention relates to linear amplifiers and, more particularly, to a class AB output amplifier stage which uses final power components with complementary field effect transistors (MOSFET)

In the planning of the class AB output states, such as those used in operational power amplifiers, it is sought to attain the following characteristics:

- high linearity, that is, low harmonic distortion;
- low distortion owing to the switching between one final power component and the other;
- high ratio between maximum output current and rest current;
- substantial independence of the rest current from the temperature and from variations in the manufacturing parameters if it is produced in an integrated circuit; and
- circuit simplicity

Various class AB output amplifier stages with complementary MOSFET transistors are known which permit one or some of the above characteristics to be attained, but none of them is able to obtain all of them, as would be desirable

The object of the present invention is to propose an output amplifier stage of the type indicated above which has all of these characteristics.

This object is achieved by producing the output amplifier stage generally defined and characterised in the first of the claims following the present description.

The invention and the advantages derived therefrom will become clearer from the following description of some of its embodiments given purely by way of non-limiting example with reference to the appended drawings in which:

- Figure 1 is a basic circuit diagram, partially in block form, of a class AB output stage according to the invention;
- Figure 2 is a basic circuit diagram showing a variant of the diagram of Figure 1; and
- Figures 3, 4 and 5 are circuit diagrams of three embodiments of the output stage in class AB according to the invention.

In Figure 1, two power MOSFET transistors that is, MOS-type field effect transistors, are indicated Qpf and Qnf. They are complementary to one another, more precisely, the first is a p-channel transistor and the second is an n-channel transistor, and are connected in push-pull manner as final components of an AB class output amplifier stage. The drain electrodes of the two transistors are connected to one another and constitute the output terminal, indicated OUT, of the stage and the source electrodes are connected to a first, positive terminal indicated +Vcc and to a second, negative terminal indicated -Vcc of a voltage supply, respectively. The output terminal OUT is connected by means of a load Zo to a reference terminal, repre-

sented by the earth symbol, which is at an intermediate potential relative to the potentials of the terminals +Vcc and -Vcc

Two differential-type transconductance amplifiers, designated Tp and Tn, have their respective output terminals connected to the gate electrodes of the transistors Qpf and Qnf respectively, the respective inverting input terminals connected to one another so as to form the input terminal, designated IN, of the stage, and the respective non-inverting input terminals each connected to the output terminal OUT by means of respective feedback systems, indicated Fp and Fn respectively.

Two voltage generators, indicated Vref(Qpf) and Vref(Qnf) are each connected by means of a respective resistor Rp and Rn between the gate electrodes of the transistors, Qpf and Qnf respectively and the supply terminals +Vcc and -Vcc respectively

The transconductance amplifiers Tp and Tn and the feedback systems Fp and Fn are dimensioned such that the output current of the transconductance amplifiers is substantially zero in rest conditions, that is, with the respective inputs at the same voltage. The voltage generators Vref(Qpf) and Vref(Qnf) are dimensioned such that, in the same rest conditions, the voltages between the gate and source electrodes of the transistors, Qpf and Qnp respectively, are such that they cause current of a predetermined value, substantially equal for both transistors, which is the rest current of the stage, to pass. In these conditions, no current is supplied to the load Zo and no current passes through the resistors Rp and Rn

Any change in these conditions, by virtue, for example, of the application of a signal between the input terminal IN and earth, causes an imbalance in both amplifiers Tp and Tn and, therefore, causes the passage of currents Itoutp and Itoutn of opposite signs in the output terminals of both amplifiers and through the resistors connected thereto, Rp and Rn respectively. The voltage drops at the resistors Rp and Rn in turn cause variations of an opposite sign in the voltages Vgs between the gate and source of the final transistors, Qpf and Qnf respectively. Consequently, there are corresponding variations in the conduction of the two transistors and thus variations of opposite signs in the respective drain currents Idp and Idn and the passage of an output current Iout through the load Zo which is equal to the difference between the drain currents of the two transistors.

When dimensioning the circuit, it should be borne in mind that, if Vgsmax(Qpf) and Vgsmax(Qnf) are the voltages between the source and drain of the two transistors enabling the maximum drain currents to be obtained, Itmax(Tp) and Itmax(Tn) are the maximum output currents of the two

transconductance amplifiers, R_p and R_n represent the resistances of the resistors shown with the same reference symbol, and $V_{ref}(Q_{pf})$ and $V_{ref}(Q_{nf})$ represent the voltages of the voltage generators indicated by the same reference symbol, the following conditions should be respected:

$$I_{tmax}(T_p) \cdot R_p + V_{ref}(Q_{pf}) \geq V_{gsmax}(Q_{pf}) \text{ and} \\ I_{tmax}(T_n) \cdot R_n + V_{ref}(Q_{nf}) \geq V_{gsmax}(Q_{nf})$$

Furthermore, the amplifiers T_p and T_n should have transconductance values G_{mp} , G_{mn} such that the system is stable for a given feedback system and for given characteristics of the final transistors Q_{pf} and Q_{nf} and of the load Z_o .

Preferably, the stage is produced symmetrically, that is, with its parts and its components marked p equal and complementary to the parts and components marked n.

It should be used that the feedback systems F_p and F_n , which are used for determining the gain of the stage and for rendering the circuit more stable and more linear, could in some applications be omitted and in their place suitable reference voltage generators could be used for application to the inverting terminals of the amplifiers T_p and T_n . Furthermore, instead of two different feedback systems, a single system could be provided which is common to the two transconductance amplifiers.

An example of a simple common feedback system is shown in Figure 2 where, as a single variant relative to Figure 1, the non-inverting terminals of the amplifiers T_p and T_n are connected to one another and to the intermediate node of a voltage divider, formed by two resistors, indicated R_{f1} and R_{f2} , connected between the output terminal OUT and the earth. The ratio between the resistances of the two resistors determines the gain of the stage.

In the embodiment shown in Figure 3, in which the same reference numerals as used in Figure 2 indicate identical or equivalent elements, the first transconductance amplifier T_p , that is, the one which controls the final p-channel transistor, Q_{pf} , is a differential circuit formed by a pair of n-channel MOSFET transistors arranged with common sources, indicated Q_{nd1} and Q_{nd2} and by a first constant current generator I_p connected between the common source electrodes and the supply terminals $-V_{cc}$. The drain electrode of the transistor Q_{nd2} is connected to the supply terminal $+V_{cc}$ and that of the transistor Q_{nd1} is the output terminal of the first transconductance amplifier and is therefore connected to the gate electrode of the final transistor Q_{pf} . In an entirely symmetrical manner, the second transconductance amplifier T_n , which is the one controlling the final n-channel

transistor, Q_{nf} , is formed by a pair of p-channel MOSFET transistors arranged with common sources, indicated Q_{pd1} and Q_{pd2} , and by a second constant current generator I_n connected between the common source electrodes and the feed terminal $+V_{cc}$. The drain electrode of the transistor Q_{pd2} is connected to the supply terminal $-V_{cc}$ and that of the transistor Q_{pd1} is the output terminal of the second transconductance amplifier and is therefore connected to the gate electrode of the final transistor Q_{nf} .

The gate electrodes of the transistors Q_{nd2} and Q_{pd2} are the non-inverting terminals of the two transconductance amplifiers and are therefore both connected to the feedback system R_{f1} , R_{f2} and the gate electrodes of the transistors Q_{nd1} and Q_{pd1} are the inverting terminals of the same amplifiers and are connected to the input terminal IN of the stage.

In this example, the reference voltage generators for determining the rest current of the stage consist, respectively, of the resistor R_p and of the series connection of the transistors Q_{nd1} and of the constant current generator I_p , as regards the polarisation of the final transistor Q_{pf} , and of the resistor R_n and the series connection of the transistor Q_{pd1} and of the constant current generator I_n , as regards the polarisation of the final transistor Q_{nf} . The transconductance amplifiers and the reference voltage generators have components in common such that it is not possible to show them separately as, for example, in Figure 2.

The currents I_p and I_n of the two constant current generators, indicated by the same reference of the respective generators, should satisfy the following conditions:

$$I_p = N \cdot V_{ref}(Q_{pf})/R_p \text{ and} \\ I_n = N \cdot V_{ref}(Q_{nf})/R_n$$

in which N is a number which depends on the dimensional ratio between the transistors of the two differential pairs, and $V_{ref}(Q_{pf})$ and $V_{ref}(Q_{nf})$ are the voltages which are to be applied between the gate and source of the final transistors Q_{pf} and Q_{nf} in order to attain the rest current. The dimensional ratio between the transistors, and therefore the number N , is determined by taking account of the maximum gate-source voltage V_{gsmax} of the final transistors, that is, that which corresponds to the maximum drain current. When considering the upper section of the circuit, if $V_{gsmax}(Q_{pf}) \leq 2 \cdot V_{ref}(Q_{pf})$, the transistors Q_{nd1} and Q_{nd2} can have equal areas: in fact, in these conditions, at rest, the current I_p is divided into equal parts between Q_{nd1} and Q_{nd2} , such that $V_{ref}(Q_{pf}) = \frac{1}{2} I_p \cdot R_p$ whilst, with the differential amplifier completely unbalanced, the voltage drop at R_p is $V_{gsmax} = I_p \cdot R_p$.

If, on the other hand, $V_{gsmax}(Q_{pf}) \geq 2V_{ref}(Q_{pf})$, the area of Q_{nd1} should be correspondingly smaller than that of Q_{nd2} . For example, if $V_{ref}(Q_{pf})/R_p = 11 \cdot V_{gsmax}(Q_{pf})/R_p$, the area of the transistor Q_{nd1} should be one tenth of that of Q_{nd2} and $I_p = 11 \cdot V_{ref}(Q_{pf})/R_p$. Similar considerations apply for the lower section of the circuit.

In the embodiment of Figure 4, the reference voltage generators $V_{ref}(Q_{pf})$ and $V_{ref}(Q_{nf})$ are formed by two MOSFET transistors, one, indicated Q_{pref} , being p-channel and the other, indicated Q_{nref} , being n-channel, with the respective gate and drain electrodes connected together at the two terminals of a constant current generator, indicated I_{ref} , and the respective source electrodes connected respectively to the positive terminal $+V_{cc}$ and to the negative terminal $-V_{cc}$ of the voltage supply. The transconductance amplifiers T_p and T_n are differential amplifiers each comprising a pair of MOSFET transistors arranged with common sources. The amplifier T_p comprises two n-channel transistors Q_1 and Q_2 , with the source electrodes connected to the terminal $-V_{cc}$ by means of a constant current generator $I_{p'}$ and two p-channel transistors, Q_3 and Q_4 , connected as load elements between the drain electrodes of Q_1 and Q_2 and the terminal $+V_{cc}$ and forming a current mirror circuit. As the output terminal of the amplifier T_p , the drain electrode of Q_1 is connected to the gate electrode of the transistor Q_{pf} and to a terminal of the resistor R_p . The amplifier T_n is formed in an entirely similar but complementary manner to the amplifier T_p and comprises common source p-channel transistors Q_5 , Q_6 , a constant current generator $I_{n'}$ and current mirror load n-channel transistors, Q_7 and Q_8 .

In the embodiment of Figure 5, the reference voltage generators $V_{ref}(Q_{pf})$ and $V_{ref}(Q_{nf})$ are identical to those described in relation to Figure 4, however, the transconductance amplifiers T_p and T_n are separate and connected to one another. More particularly, the two transconductance amplifiers are formed of a circuit structure of a differential type in which the components cannot be considered as belonging exclusively to one or other amplifier but the operating diagram is still that of Figure 2. The differential structure comprises a first circuit branch comprising two MOSFET transistors Q_1 and Q_3 , the first being n-channel and the second being p-channel, connected by their gate electrodes to the respective drain electrodes, with the source electrodes joined together so as to form an inverting input terminal IN^- of the differential circuit and with the drain electrodes connected to the positive terminal $+V_{cc}$ and to the negative terminal $-V_{cc}$ of the supply respectively by means of respective constant current generators G_1 and G_2 . The differential structure also comprises a second

circuit branch with two MOSFET transistors Q_2 and Q_4 , the first being n-channel and the second being p-channel, with their source electrodes connected together so as to form a non-inverting input terminal IN^+ of the differential circuit, their gate electrodes connected to the gate electrodes of the transistors Q_1 and Q_3 respectively, and their drain electrodes connected respectively to the positive supply terminal $+V_{cc}$ through a p-channel MOSFET transistor Q_5 having the gate electrode connected to the drain electrode and to the negative supply terminal $-V_{cc}$ via the n-channel MOSFET transistor Q_8 , connected as the transistor Q_5 . Two p-channel transistors, Q_6 and Q_7 , and two n-channel transistors, Q_9 and Q_{10} , are connected to the transistors Q_5 and Q_8 , respectively, in a current mirror configuration. The drain electrode of the transistor Q_6 is connected to the gate electrode of the final n-channel transistor Q_{nf} and the drain electrode of the transistor Q_7 is connected to the gate electrode of the final p-channel transistor Q_{pf} . Similarly, the drain electrodes of the transistors Q_9 and Q_{10} are connected to the gate electrodes of Q_{pf} and Q_{nf} respectively. The input terminals of the differential structure, if necessary, are connected to suitable polarisation means, not shown. It should be noted that, in this embodiment, the input signal is applied between the two input terminals IN^- and IN^+ and that no feedback system is provided between the input and the output of the stage.

The operation of the circuit of Figure 5 will now be considered. At rest, that is, when there is no signal between the input terminals IN^- and IN^+ , a current determined by the two current generators G_1 and G_2 passes through the transistors Q_1 and Q_3 . The same current which passes through Q_1 and Q_3 also passes through the transistors Q_2 and Q_4 if they are dimensionally equal to the respective transistors Q_1 and Q_3 . This same current passes both through the transistor Q_5 , and is reflected in the transistors Q_6 and Q_7 , and the transistor Q_8 , and is reflected in the transistors Q_9 and Q_{10} . Since the current passing in Q_6 is equal to the current passing in Q_{10} , no current passes through the resistor R_n and the voltage at the gate electrode Q_{nf} is the reference voltage determined by the reference voltage generator $V_{ref}(Q_{nf})$, formed by the transistor Q_{nref} and by the constant current generator I_{ref} . Similarly, since the current passing in Q_9 is equal to the current passing in Q_7 , no current passes through the resistor R_p and the voltage at the gate electrode of Q_{pf} is the reference voltage determined by the reference voltage generator $V_{ref}(Q_{pf})$, formed by the transistor Q_{pref} and by the constant current generator I_{ref} . Therefore, the same current, that is, the rest current, passes through the final transistors Q_{pf} and Q_{nf} ,

and no current passes through the load Z_o .

An imbalance of the differential circuit owing to the application of a signal between the two input terminals IN^- and IN^+ , will now be considered, for example in the case in which the potential at the input terminal IN^+ is greater than that at the input terminal IN^- . This imbalance causes an increase in the current in Q_4 and a reduction of the current in Q_2 and, therefore, an increase in the currents in Q_8 , Q_9 and Q_{10} and a reduction of the currents in Q_5 , Q_6 and Q_7 . Owing to the different currents in Q_6 and in Q_{10} and of the different currents in Q_9 and Q_7 , respective different currents will pass in the resistors R_n and R_p , such that the voltage between the gate and source electrodes of the transistor Q_{pf} , $V_{gs}(Q_{pf})$, increases relative to the reference voltage $V_{ref}(Q_{pf})$ and that of Q_{nf} decreases relative to the reference voltage $V_{ref}(Q_{nf})$. Therefore, the currents passing through the two final transistors are also different, such that a current, which is the difference between the currents of the two final transistors, passes through the load Z_o .

From a practical analysis of the different embodiments described above, it is noted that the output amplifier stage according to the invention has high linearity and low distortion when switching between one final transistor and the other since there is no discontinuity in the command of the final transistors and since the circuits determining the rest current and the circuits supplying the required current to the load function substantially independently of one another. This further enables a high ratio to be obtained between the maximum output current and the rest current, since the rest current can be set with great precision at very low values and the dynamics of the final components are not limited at all by the control circuit. The dependence on the temperature and on the variations in the parameters of the process can also be limited to a great extent by virtue of the possibility of compensation deriving from the total symmetry of the control circuits of the two complementary final components. Finally, the simplicity of the circuit is evident and therefore the stage according to the invention lends itself to production in integrated circuits with very restricted areas.

Although only some embodiments of the invention have been illustrated and described, it is evident that numerous variations and modifications are possible within the scope of the same inventive concept. For example, the transconductance amplifiers could be produced with bipolar transistors instead of with MOSFET transistors and the resistors R_p and R_n could be resistive means having substantially the structure of MOSFET transistors with the drain and gate electrodes short-circuited; furthermore, two power components each compris-

ing more than one transistor could be provided in the place of the MOSFET power transistors Q_{pf} and Q_{nf} .

Claims

1. A class AB output amplifier stage comprising a first and a second field effect transistor power component (Q_{pf} , Q_{nf}) which are complementary to one another, each having a first and a second power electrode and a control electrode, and being connected, in push-pull manner relative to one another, by the respective first power electrodes to a first (+Vcc) and to a second (-Vcc) terminal of a voltage supply respectively, and the second power electrodes connected to one another and to an output terminal of the stage (OUT), characterised in that it comprises:
 - a first (T_p) and a second (T_n) transconductance amplifier each having an output terminal connected to the control electrode of the first (Q_{ps}) and of the second (Q_{nf}) power component respectively and an input terminal connected to the input terminal of the other transconductance amplifier, so as to form an input terminal (IN) of the stage, and being dimensioned so as to have an output current which is substantially zero in rest conditions;
 - a first ($V_{ref}(Q_{pf})$) and a second ($V_{ref}(Q_{nf})$) voltage generator connected to the control electrode of the first (Q_{pf}) and of the second (Q_{nf}) power component respectively, the voltages of these generators being selected so as to determine currents which are substantially equal through the first and second power components in rest conditions of the stage; and
 - a first (R_p) and a second (R_n) resistive means connected between the control electrode of the first (Q_{pf}) and of the second (Q_{nf}) power component respectively and the first (+Vcc) and the second (-Vcc) terminal of the voltage supply respectively.
2. A stage according to Claim 1, in which each of the transconductance amplifiers (T_p , T_n) comprises an inverting input terminal which is the above input terminal connected to the input terminal (IN) of the stage and a non-inverting input terminal, and in which the non-inverting input terminal of each of the transconductance amplifiers (T_p , T_n) is connected to a respective reference voltage generator

3. A stage according to Claim 2, in which the reference voltage generators consist of respective feedback systems (Fp, Fn) connected to the output terminal (OUT) of the stage.
4. A stage according to Claim 2, in which the reference voltage generators consist of a common feedback system (RF1, RF2) connected to the output terminal (OUT) of the stage.
5. A stage according to Claim 4, in which a reference terminal is provided which is common to the input and to the output of the stage, and in which:
 - the first and the second power components consist of a first (Qpf) and of a second (Qnf) field effect power transistor being p-channel and n-channel respectively, the first and the second power electrode being the source and drain electrodes respectively and the control electrode being the gate electrode;
 - the first transconductance amplifier (Tp) comprises a first pair of n-channel field effect transistors (Qnd1, Qnd2) in common source arrangement and a first current generator (Ip) connected between the common source electrodes and the second supply voltage terminal (-Vcc), the drain of one (Qnd2) of the transistors of the first pair being connected to the first supply terminal (+Vcc) and the drain of the other transistor (Qnd1) of the first pair being the output terminal of the first transconductance amplifier (Tp);
 - the second transconductance amplifier (Tn) comprises a second pair of p-channel field effect transistors (Qpd1, Qpd2) in the common source arrangement and a second current generator (In) connected between the common source electrodes and the first supply terminal (+Vcc), the drain of one (Qpd2) of the transistors of the second pair being connected to the second supply terminal (-Vcc) and the drain of the other (Qpd1) of the transistors of the second pair being the output terminal of the second transconductance amplifier (Tn), the gate electrodes of the transistors of the first and of the second pair being connected to one another in pairs, so as to form the above inverting terminal, which is the input terminal (IN) of the stage, and the said non-inverting terminal;
 - the first resistive means is a first resistor (Rp) connected directly between the gate electrode of the first power transistor (Qpf) and the first supply terminal (+Vcc) and the first current generator (Ip) constitutes, together with the first resistor (Rp), the first reference voltage generator (Vref(Qpf));
 - the second resistive means is a second resistor (Rn) directly connected between the gate electrode of the second power transistor (Qnf) and the second supply terminal (-Vcc) and the second current generator (In) constitutes, together with the second resistor (Rn), the second reference voltage generator (Vref(Qnf)); and
 - the feedback system comprises a voltage divider (Rf1, Rf2) connected between the output terminal (OUT) of the stage and the common reference terminal and having the intermediate node connected to the common gate electrodes of the transistors (Qnd2, Qpd2) of the two transconductance amplifiers which constitute the non-inverting terminal
6. A stage according to Claim 4, in which:
 - the first resistive means is a first resistor (Rp) connected to the first supply terminal (+Vcc) via a first p-channel field effect reference transistor (Qpref) having common drain and gate electrodes and the second resistive means is a second resistor (Rn) connected to the second supply terminal (-Vcc) via a second n-channel field effect reference transistor (Qnref) having common drain and gate electrodes, a reference current generator (Iref) being connected between the common gate and drain electrodes of the first reference transistor and the common gate and drain electrodes of the second reference transistor, so as to form the first and the second voltage generators (Vref(Qpf), Vref(Qnf)) together with the first and second reference transistors (Qpref, Qnref)
7. A stage according to Claim 6, in which the first and the second transconductance amplifiers (Tp, Tn) comprise a first and a second differential amplifier.
8. A stage according to Claim 7, in which:
 - the first differential amplifier (Tp) comprises a first pair of n-channel field effect transistors (Q1, Q2) in the common source configuration, a constant current generator (Ip) connected between the common source electrodes and the sec-

- ond supply terminal (-Vcc) and a second pair of p-channel field effect transistors (Q3, Q4) connected as load elements between the drain electrodes of the transistors of the first pair (Q1, Q2) and the first supply terminal (+Vcc) and connected between each other in the current mirror configuration; and
- the second differential amplifier (Tn) comprises a third pair of p-channel field effect transistors (Q5, Q6) in the common source configuration, a constant current generator (In) connected between the common source electrodes and the first supply terminal (+Vcc) and a fourth pair of n-channel field effect transistors (Q7, Q8) connected as load elements between the drain electrodes of the transistors of the third pair (Q5, Q6) and the second supply terminal (-Vcc) and connected to one another in the current mirror configuration.
9. A stage according to Claim 1, in which the first resistive means is a first resistor (Rp) connected to the first supply terminal (+Vcc) via a first p-channel field effect transistor (Qpref) having common drain and gate electrodes and the second resistive means is a second resistor (Rn) connected to the second supply terminal (-Vcc) via a second n-channel field effect reference transistor (Qnref) having common drain and gate electrodes, a reference current generator (Iref) being connected between the common drain and gate electrodes of the first reference transistor and the common drain and gate electrodes of the second reference transistor, so as to form the first and second voltage generators (Vref(Qpf), Vref(Qnf)) together with the first and second reference transistors (Qpref, Qnref).
10. A stage according to Claim 9, in which the first and the second transconductance amplifiers (Tp, Tn) are formed in a differential structure comprising:
- a first circuit branch inserted between the first (+Vcc) and the second (-Vcc) supply terminals and comprising, in series relative to each other, a first constant current generator (G1) with a terminal connected to the first (+Vcc) supply terminal, a first n-channel field effect transistor (Q1) with the drain electrode connected to the gate electrode, a second p-channel field effect transistor (Q3) with the drain electrode connected to the gate electrode, and a second constant current generator (G2) with a terminal connected to the second supply terminal (-Vcc), the source electrodes of the first (Q1) and second (Q3) transistors being connected to one another so as to form the inverting input terminal of the differential structure which constitutes the said input terminal (IN) of the stage;
 - a second circuit branch comprising a third and a fourth field effect transistors (Q2, Q4), the first being n-channel and the second being p-channel, with their source electrodes connected together so as to form a non-inverting input terminal (IN+) of the differential structure which constitutes a further input terminal of the stage, with the respective gate electrodes connected to the gate electrodes of the first (Q1) and of the second (Q3) field effect transistors of the first branch respectively and with the respective drain electrodes connected to the common drain and source electrodes of a fifth and a sixth field effect transistor, respectively, p-channel (Q5) and n-channel (Q8) having respective source terminals connected to the first (+Vcc) and to the second (-Vcc) supply terminal respectively;
 - a first pair of p-channel field effect transistors (Q6, Q7) having the gate electrodes connected to the gate electrodes of the fifth field effect transistor (Q5), the source electrodes connected to the first supply terminal (+Vcc) and the drain electrodes connected one to the control electrode of the second power component (Qnf) and the other to the control electrode of the first power component (Qpf); and
 - a second pair of n-channel field effect transistors (Q9, Q10) having the gate electrodes connected to the gate electrode of the sixth (Q8) field effect transistor, the source electrodes connected to the second supply terminal (-Vcc) and the drain electrodes connected one to the control electrode of the first power component (Qpf) and the other to the control electrode of the second power component (Qnf).

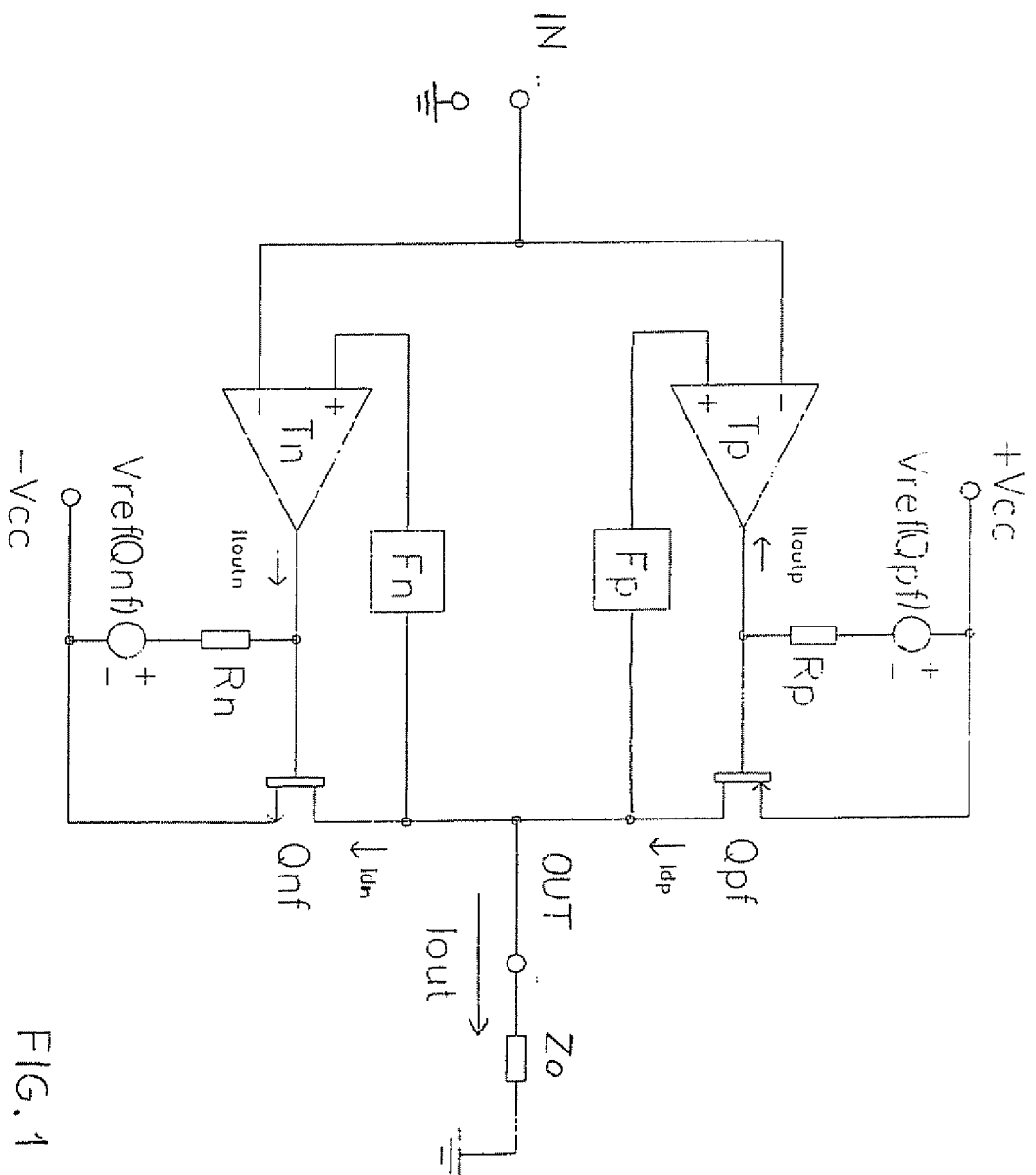


FIG. 1

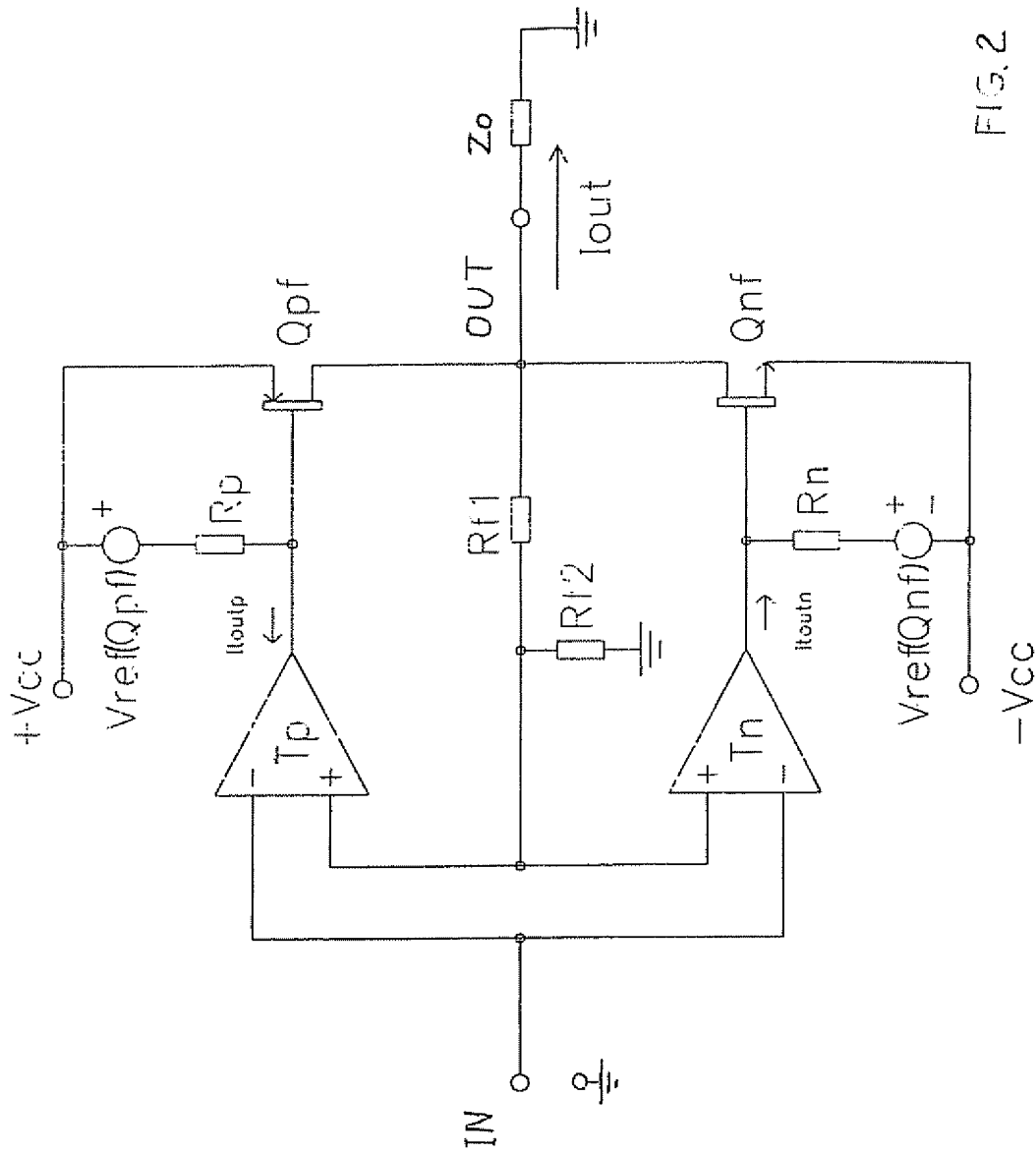


FIG. 2

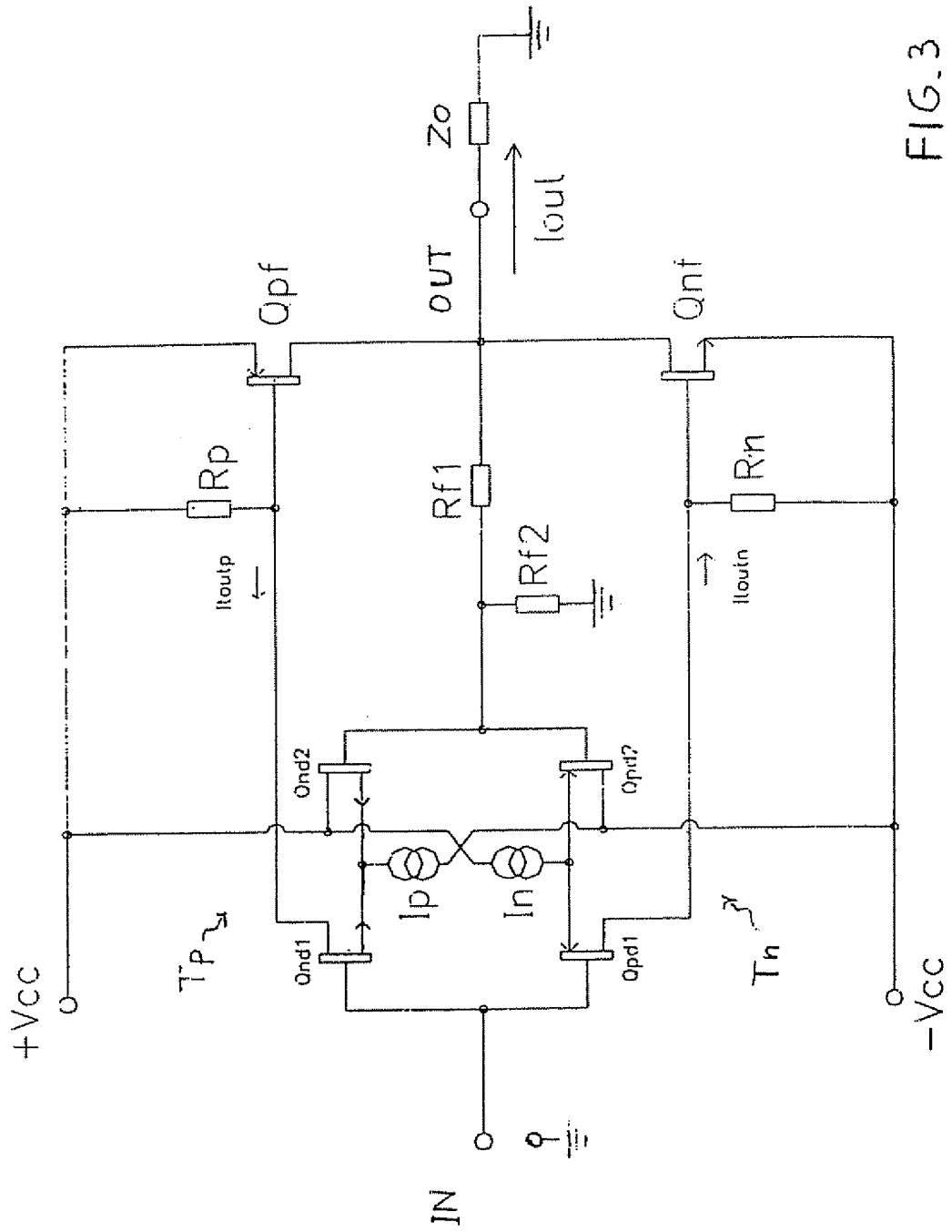


FIG. 3

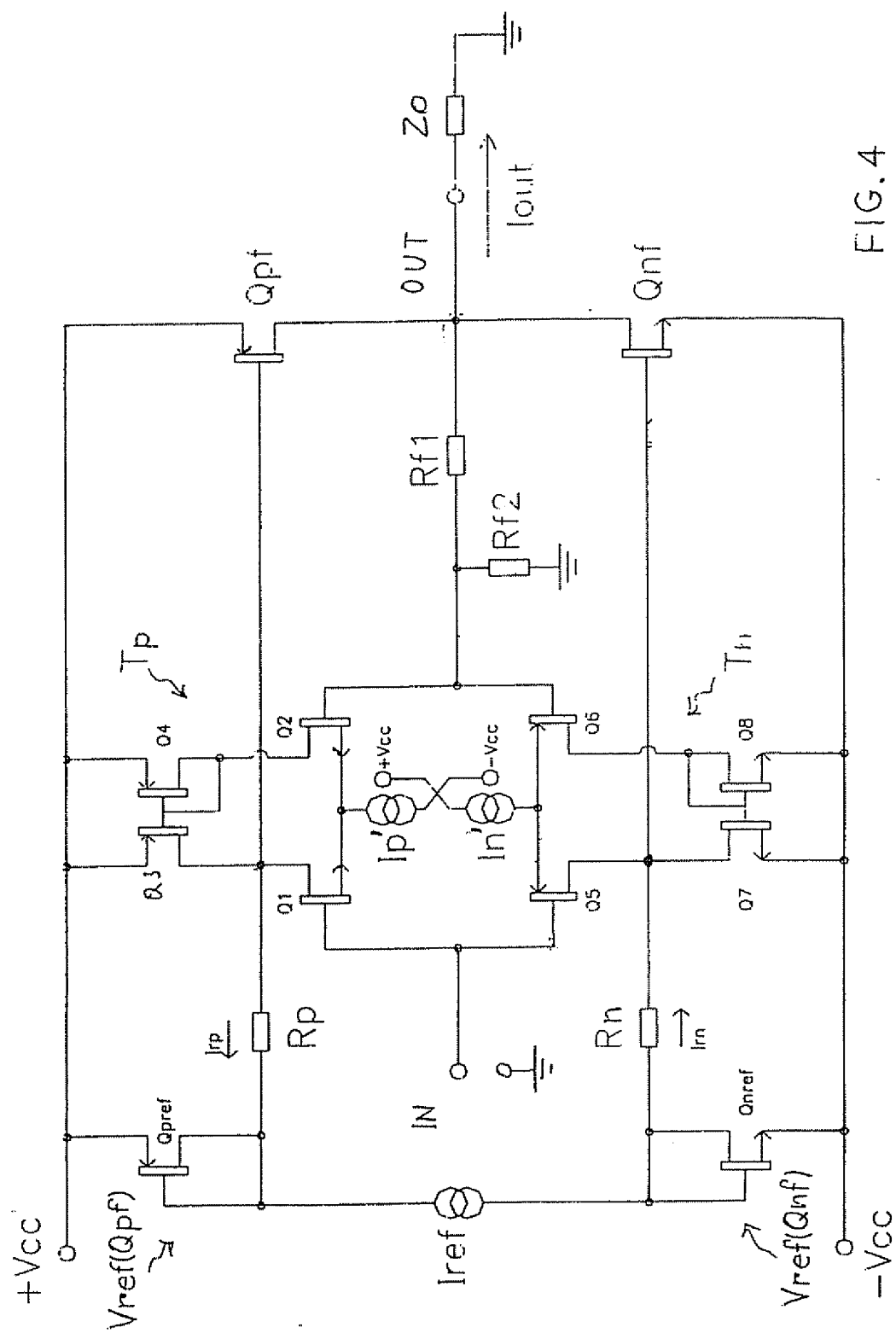


FIG. 4

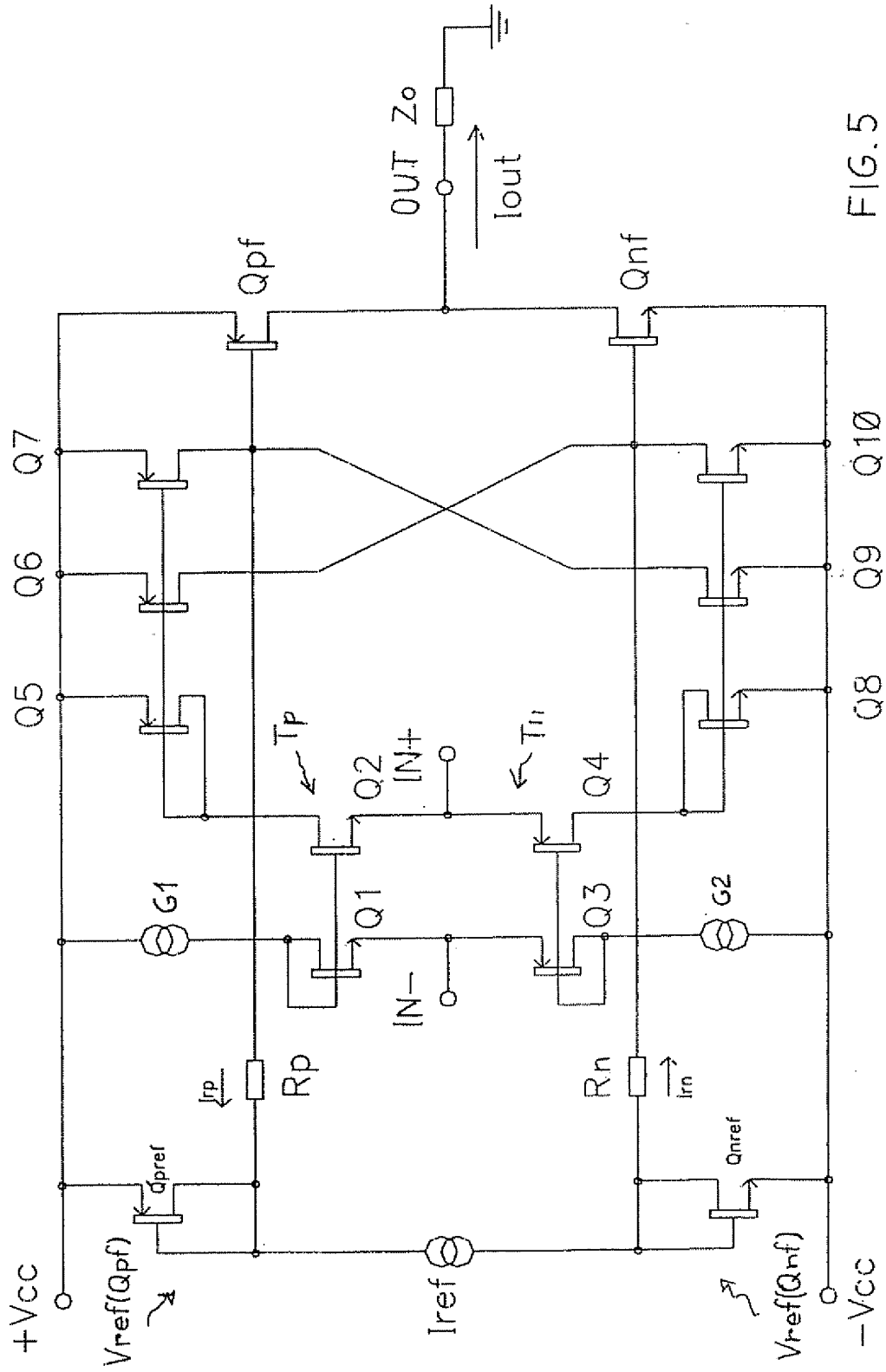


FIG. 5



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 83 0239

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	EP-A-0 535 951 (NEC CORP.) * abstract; figure 2 * ---	1	H03F1/00 H03F3/30
A	US-A-4 866 398 (GULCZYNSKI) * abstract; figure 4 * ---	2	
A	PATENT ABSTRACTS OF JAPAN vol. 12, no. 99 (E-594) 31 March 1988 & JP-A-62 230 206 (TOSHIBA CORP.) 8 October 1987 * abstract *	1,7,8	
A	US-A-5 039 953 (SU) * abstract; figure 2 * -----	10	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			H03F
The present search report has been drawn up for all claims			
Place of search BERLIN		Date of completion of the search 14 October 1994	Examiner Danielidis, S
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			